

# INTRODUCTION

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This report describes the activities of the Nuclear Science Division (NSD) for the period, January 1, 1998 to December 31, 1998. This was an extremely productive year, both in our science and in the continuing development of instrumentation which supports that science and paves the way to future research discoveries. The overviews and contributed material elsewhere in this report provide a snapshot of the year and its many scientific accomplishments.

Major milestones were reached in a number of the NSD's activities. For example, at the 88-Inch Cyclotron, the Berkeley Gas-Filled Separator (BGS) went from the construction stage, through successful commissioning and onto the beginning of its scientific program of heavy element research. The BEARS (Berkeley Experiments with Accelerated Radioactive Species) has successfully demonstrated cryo-trapping of  $^{11}\text{C}$ , with subsequent injection into and extraction from the AECR, followed by acceleration and extraction of substantial beam currents for nuclear physics research at the 88-Inch. A transfer line from the medical cyclotron in building 56 to the 88-Inch is nearing completion. In the meantime, an initial experimental program with  $^{11}\text{C}$ , obtained from 'batched mode operation' (i.e., production and cryo-freezing in bldg. 56 and trucking to the 88-Inch) has been successfully carried out. An independent effort to develop an  $^{14}\text{O}$  beam for weak interaction studies at the 88-Inch was initiated during this period. The beam development and test facility put together for this program also provides an excellent platform for any future ion source related R&D that maybe needed for a US ISOL facility. The Canadian  $8\pi$  array, ably put together by David Ward and colleagues, was reassembled in the Gammasphere cave and brought into operation during the late winter/early spring. It immediately became a major workhorse for the world-wide nuclear structure community carrying out research at the 88-Inch. A major research program in laser trapping of radioactive light elements continued during this period. With the ability of the 88-Inch to provide a 'cocktail of beams,' a systematic study of fission-fusion and other reaction mechanisms continues to yield interesting results. The nuclear chemistry effort was substantially strengthened by the addition of Professor Heino Nitsche to the UC Berkeley Chemistry Department and the NSD. A particularly noteworthy achievement in the nuclear chemistry program was the identification of a long sought plutonium isotope,  $^{231}\text{Pu}$ . Darleane Hoffman and Carola Laue were the discoverers. Other developments include continued R&D on the next generation  $\gamma$ -ray detector, GRETA (Gamma-Ray Energy Tracking Array), and a successful GRETA Physics Workshop held in March 1998 at LBNL to identify its physics opportunities. A proposal for the return of Gammasphere to the 88-Inch Cyclotron, after its operation at Argonne coupled to the FMA, was submitted to DOE and approved for March 2000. Progress continued throughout this year on the 3rd Generation ECR source for the 88-Inch Cyclotron. This source will provide the heaviest beams at energies above the Coulomb Barrier for the 88-Inch Cyclotron research community.

In our relativistic nuclear collisions (RNC) program, analyses of experiments spanning Bevalac, AGS, SPS and RHIC energies continued at a high level. A common physics theme, weaving itself throughout these efforts, is the observation of nuclear matter flow. RNC researchers continue to lead in this scientific thrust in these experiments: EOS (Bevalac), EOS@AGS (E895) and NA49 at CERN. It is expected that 'flow' will be one of the early observables with STAR (Solenoidal Tracker at RHIC) during year one at RHIC. Other focus areas in our experimental efforts leading to RHIC are baryon stopping and strangeness production. The STAR project, under the guidance of Jay Marx, continued to move forward to day one operation at RHIC in the period of late FY99. The STAR TPC, under the direction of Howard Wieman, underwent further successful testing after its November 1997 move to Brookhaven/RHIC. The STAR detector continues to meet all milestones and is (at the time of this writing) in position in the Wide Angle Hall at RHIC. With major responsibilities for STAR project construction and guidance nearing an end, the RNC group is making the transition to STAR physics. To enable this, an internal meeting was held in June 1998 to identify major areas of physics interest. Potential areas include: soft hadron physics, strangeness content, exotica, peripheral collisions to look at " $\gamma\gamma$ " collisions, high  $p_t$  and RHIC spin. STAR physics analyses will require substantial data reduction and computational capabilities for the group. Besides using the RCF (RHIC Computing Facility) at Brookhaven, we are actively working toward the development of additional computing capacity at LBNL. This is required because of the large data sets expected from STAR and the need for comparable simulated data for physics analyses and interpretation. Our Grand Challenge activities, focused on large data sets and data management tools, continued throughout the year Instrumentation development, while taking a back seat to the need to bring STAR on-line, continues as a major activity of this group. Recent attention has been focused on a next generation vertex detector, a micro-TPC, with the capability of providing possible access to D-meson physics in STAR. Throughout this year increasing numbers of RNC scientists are spending more time at RHIC as we build toward STAR commissioning and STAR day one physics.

The Institute for Particle and Nuclear Astrophysics (INPA), a joint venture with the Physics Division, continues to focus much of its activity on neutrino astrophysics and potential next-generation neutrino detectors such as KamLAND (in Japan) and AMANDA (at the South Pole). R&D activities, across divisional lines, were carried out with application to existing, near future and far future neutrino detectors in ice, water or underground. The Sudbury Neutrino Observatory (SNO), where NSD researchers have major responsibilities, began its heavy water fill and its anticipated that first physics results will commence in 1999.

The Nuclear Theory program continued at a strong pace, with its principal focus on relativistic nuclear collisions. A strong collaboration with the Institute for Nuclear Theory in Seattle continues, including co-organization of a workshop, held in Seattle, on Probes of Dense Matter. The close interaction between our theory effort and experimental programs was further strengthened by the movement of the RNC group from Bldg. 50A to their former location in Bldg. 70 next to the Nuclear Theory Group. Besides the work in relativistic nuclear collisions, strong theoretical efforts in the area of neutron star physics and low-

energy nuclear reactions and dynamics continues to enrich the NSD's programs. A strong visitor program continues to enrich the whole division.

The Isotopes Project continues to focus on electronic data dissemination and on evaluation of nuclear data. Collaborative efforts with the NNDC (National Nuclear Data Center) at Brookhaven and the other elements of the US nuclear data program are being strengthened. One of the inherent strengths of the Isotopes Project has been its traditional focus of having individual researchers involved in one or more basic research programs. In the last few years, a focus area of nuclear astrophysics has developed. To further enhance this, the Isotopes Project, in collaboration with others in the US data program (at national laboratories and universities) submitted a proposal to the DOE for support of a broad national data effort in the area of nuclear astrophysics--the proposal has been reviewed and a decision is pending.

In collaboration with the U.S. nuclear science community we continued working on the Nuclear Science Wall Chart. A very successful conclusion was reached this last year and the Wall Chart is now available through the auspices of the Contemporary Physics Education Project (CPEP). This is an excellent educational tool and we thank all in the nuclear science community who participated in this process.

One sad note to add to this introduction. A giant of U.S. science in the 20th century, Glenn Seaborg, passed away in February 1999. His tremendous contributions to our science, educational and public institutions is simply without equal.

As has become standard, we no longer printing a hard copy of the annual, but rather publish it on the World Wide Web (WWW) and, this years, as a CD-ROM. I want to thank Rick Firestone, whose careful hand has guided this edition to completion. Also Michael Anderson and Virginia Pritchett were of great assistance in getting all the contributions to this report in shape. Please address any comments or suggestions to Rick Firestone, this year's editor. For additional information about the NSD and its programs, please visit our home page on the WWW ([http://user88.lbl.gov/nsd\\_home.html](http://user88.lbl.gov/nsd_home.html)). You can also access us through the Berkeley Lab home page (<http://www.lbl.gov>). Please visit us!